

# AN AGILE BEAM TRANSMIT ARRAY USING COUPLED OSCILLATOR PHASE CONTROL

Ronald J. Pogorzelski, Rocco P. Scaramastra, John Huang, Robert J. Beckon, Steve M. Petree, and Cosme Chavez

Jet Propulsion Laboratory  
California Institute of Technology  
4800 Oak Grove Drive  
Pasadena, CA 91109-8099  
e-mail: pogo@jpl.nasa.gov

## Abstract:

A few years ago York and colleagues suggested that injection locking of voltage controlled oscillators could be used to implement beam steering in a phased array [1]. The scheme makes use of the fact that when an oscillator is injection locked to an external signal, the phase difference between the output of the oscillator and the injection signal is governed by the difference between the injection frequency and the free running frequency of the oscillator (the frequency to which the oscillator is tuned). Thus, if voltage controlled oscillators (VCOs) are used, this phase difference is controlled by an applied voltage. Now, if a set of such oscillators are coupled to nearest neighbors, they can be made to mutually injection lock and oscillate as an ensemble. If they are all tuned to the same frequency, they will all oscillate in phase. Thus, if the outputs are connected to radiating elements forming a linear array, the antenna will radiate normal to the line of elements. Scanning is accomplished by antisymmetrically detuning the end oscillators in the array by application of a pair of appropriate voltages to their tuning ports. This results in a linear phase progression across the array which is just the phasing required to scan the beam. The scan angle is determined by the degree of detuning.

We have constructed a seven element one dimensional agile beam array at S-band based on the above principle. Although, a few such arrays have been built in the past, this array possesses two unique features. First, the VCO MMICs have buffer amplifiers which isolate the output from the tuning circuit, and second, the oscillators are weakly coupled to each other at their resonant circuits rather than their outputs. This results in a convenient isolation between the oscillator array design and the radiating aperture design. An important parameter in the design is the so called coupling phase which determines the phase shift of the signals passing from one oscillator to its neighbors. Using this array, we have been able to verify the theoretical predictions concerning the effect of this phase on both the locking range and ensemble frequency of the array. However, the scan range achieved fell somewhat short of the theoretical value because of the amplitude variation of the oscillator outputs with tuning.

- [1] P. Liao and R. A. York, "A New Phase Shifterless Beam-Scanning Technique Using Arrays of Coupled Oscillators," *IEEE Trans., MTT-41*, pp. 1810-1815, Oct. 1993.